3.2. SPECIAL PROJECTS

3.2.1. AN ANALYSIS OF 10-DAY ISENTROPIC FLOW PATTERNS FOR BARROW, ALASKA: 1985-1992

Atmospheric transport patterns to BRW were investigated using a newly developed isentropic model described in CMDL Summary Report No. 21 [*Peterson and Rosson*, 1993]. The new model features a layer-averaged mode that is activated whenever an air parcel traveling isentropically approaches the earth's surface and a dynamic preprocessing program that ensures trajectories always arrive at a constant, predetermined altitude. Some highlights of this study [*Harris and Kahl*, 1994] are described below.

Ten-day back trajectories arriving above BRW at 500 m, 1500 m, and 3000 m asl were calculated for the 8-year study period. Cluster analysis was used to summarize trajectories for the entire 8 years, for each year individually, and for each month (e.g., eight January's, eight February's, etc.) The focus of this report is only on some of these results, particularly those relating to transport of Arctic haze to BRW.

Figure 3.18 shows the means of each of the six transport clusters determined for the middle arrival elevation (1500 m asl) where flow is near and usually above the inversion level. Two cluster means in Figure 3.18 indicate transport from south of BRW. Both of these, clusters 1 and 3, have cyclonic curvature, consistent with transport from the area of the Aleutian Low. On average, southerly transport occurs one third of the time. Approximately one quarter (26%) of trajectories to BRW fall into cluster 4, which depicts very light northerly and northwesterly flow, with 10-day origins south of 80°N in the East Siberian Sea. The flow pattern with the next highest frequency (15%) is represented by the mean for cluster 6. It shows moderate northwesterly flow and an origin for trajectories in the central polar basin. Cluster 2, representing 14% of flow to Barrow, has a stronger westerly component than that for cluster 6 and a 10-day origin over north-central Russia near the Taymyr Peninsula. Finally, the mean for cluster 5 indicates northeasterly flow from the Canadian Archipelago with a frequency of 12%. Notably absent at this level are any cluster means showing transport within 10 days from either Europe or the contiguous United States.

To more precisely quantify transport from three source regions of particular interest, trajectories were counted that intersected the source boxes shown in Figure 3.19. Although no cluster means originate over Europe for the 1500-m arrival elevation, this region was investigated because it is often cited as a significant source of Arctic haze. Trajectories were counted over the Taymyr region because the cluster means indicated this as a consistent source at all three levels. The north Pacific region is of interest as the most direct source of heat transported to Barrow. Table 3.12 presents the results tabulated according to arrival elevation. The percent frequency of transport from each region is shown, followed in parentheses by the average transport time in days.

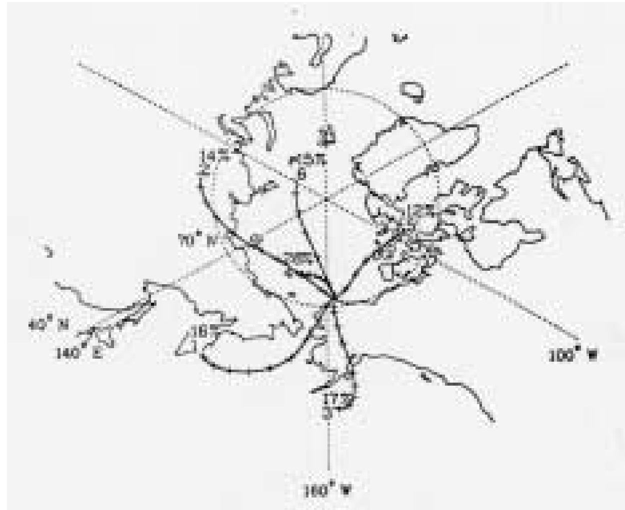

Fig. 3.18. Atmospheric flow patterns for the period 1985-1992 depicted by cluster-mean back trajectories arriving at Barrow at 1500 m asl. Plus signs indicate 1-day upwind intervals. The numbers 10-days upwind of Barrow show (top) the percentage of trajectories occurring in that cluster and (bottom) the cluster number (1-6) used for identification.

March and April trajectories were analyzed in this way (not shown) because recent studies have found decreasing trends in aerosol concentration [*Bodhaine and Dutton*, 1993] and sea-ice extent, and an increasing trend in surface temperature [*Chapman and Walsh*, 1993] during spring. The source region analysis presented no evidence of a significant change in transport that may have been linked to these trends. It is quite likely that our 8-year study period is too short to reveal a true climate change. It could also be that the spring warming seen by *Chapman and Walsh* [1993] is primarily a radiative effect, without an identifiable transport component. *Bodhaine and Dutton* [1993] hypothesize that the decreasing aerosol trend they saw resulted from decreased anthropogenic emissions.

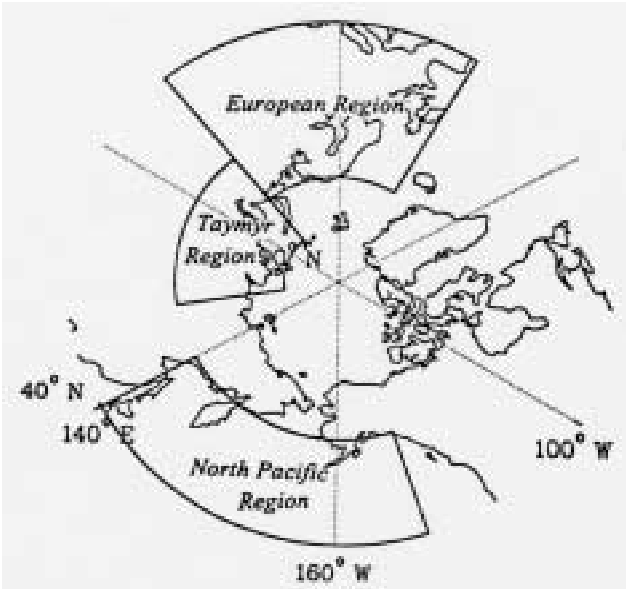

Fig. 3.19. Three potential source regions in which trajectories were tabulated: Europe, north-central Russia near the Taymyr Peninsula, and the north Pacific.

Figure 3.20 shows contour elevation plots of the average modeled transport surfaces for January 1992 for the (*a*) 500-m asl arrival elevation; (*b*) 1500-m asl arrival elevation; and (*c*) 3000-m asl arrival elevation. The surfaces shown in Figure 3.20 are intended to convey a sense of the vertical motion that an air parcel may experience on its journey to Barrow. The contour levels are not intended to imply preferred transport from any particular area. Rather, they are intended to answer the question: If an air parcel transported isentropically to the specified arrival elevation at Barrow were to pass over a certain area, at what altitude would the transport likely take place? Aside from the prominent topography of the Tibetan Plateau, the Rocky Mountains, and the Greenland Ice sheet, the isentropic features of the extratropical northern hemisphere are evident. Isentropic surfaces on individual days during the haze season will vary at times from the January means shown here. Inspection of other winter-spring months proved the surfaces in Figure 3.20 to be representative of the season.

TABLE 3.12. Percent Frequency of Origin and (Average Transport Time in Days) According to Arrival Elevation

Arrival Elevation (m asl)	Europe	Taymyr	North Pacific
500	1.3 (8.0)	21.1 (6.3)	19.8 (4.2)
1500	4.4 (7.6)	24.1 (5.9)	36.3 (4.1)
3000	11.0 (7.0)	23.6 (5.2)	50.1 (3.6)

The lowest transport level, shown in Figure 3.20*a*, is quite flat, indicating travel mostly in the near-surface layer. The higher isentropic surfaces (Figures 3.20*b* and 3.20*c*) are more peaked over the polar basin. In addition, the higher surfaces extend downward from Barrow to the south, whereas the lowest surface is limited in downward extent from Barrow. The result is that upper-level trajectories will encounter more vertical motion than lower ones.

The shape of the isentropic surfaces may have relevance to pollution transport to Barrow, if pollution is assumed to be confined to the lower levels at its source. Table 3.12 shows that transport occurs from the Taymyr region at a frequency greater than 20% at all three levels. However, the pollution assumption implies that direct transport from the Taymyr region must be close to the ground, following a surface similar to that shown in Figure 3.20*a*. Europe is only an occasional origin for 10-day back trajectories at the lower levels, but trajectories arriving at 3000-m asl originate from Europe 11% of the time. Cluster means (not shown) and the average transport surface (Figure 3.20*c*) favor Scandinavia as opposed to midlatitude eastern European sources at this level.

Because of the shape of the isentropic surfaces, trajectories generally ascend from the south and descend from the polar region to BRW. The effect of the isentropic vertical parameterization is not significant for near-surface trajectories, but higher level trajectories could be markedly different than their isobaric counterparts, depending on the degree of wind shear and temperature differences encountered during transport. It appears that isentropic transport to BRW can be slower than horizontal transport because wind speeds are often less along the lower periphery of the isentropic surfaces compared with those on isobaric surfaces.

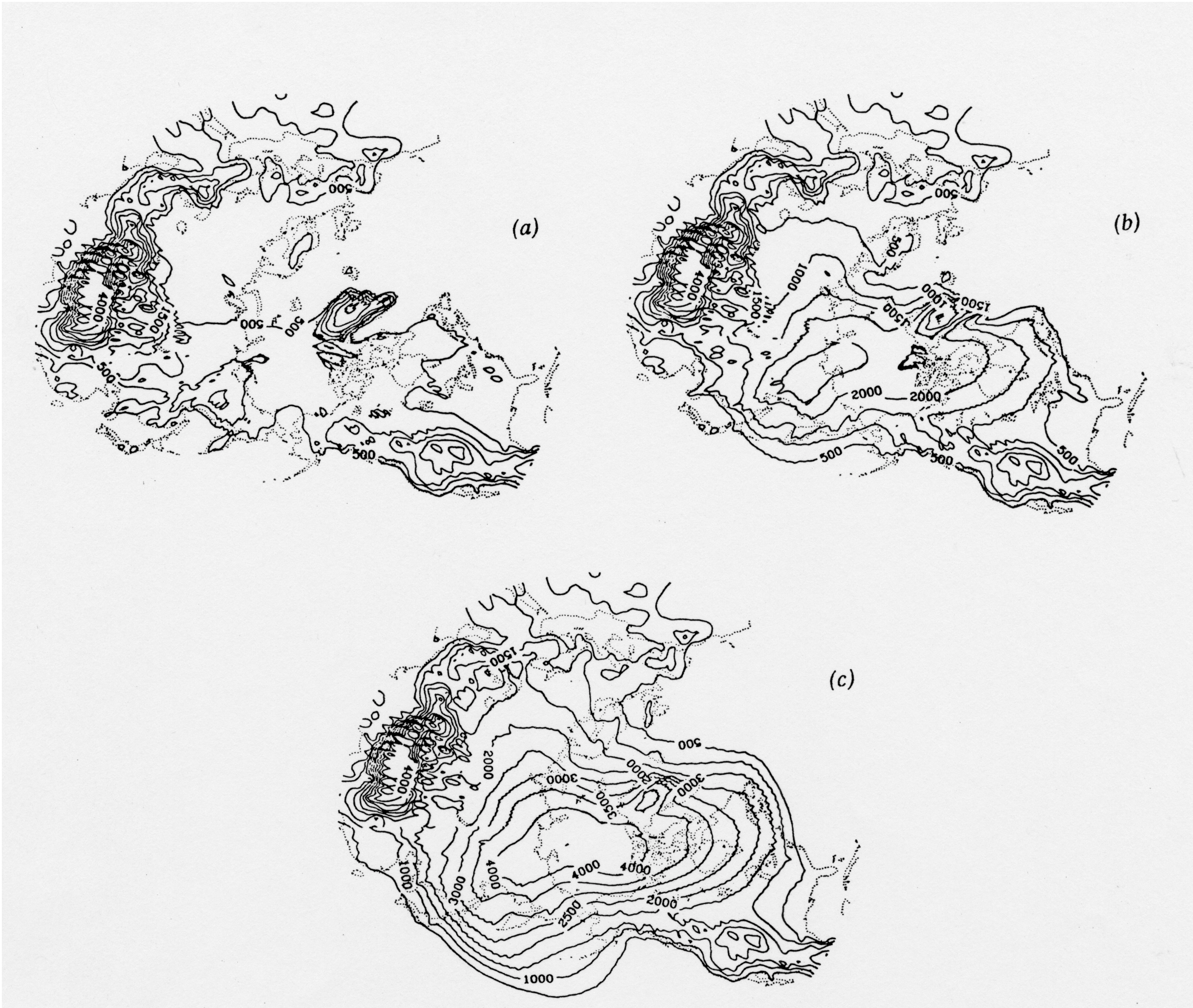

Fig. 3.20. Contour elevation plots (m asl) of the average transport surfaces for January 1992 at the (*a*) 500 m asl arrival elevation, (*b*) 1500-m asl arrival elevation, and (*c*) 3000 m asl arrival elevation. The contour interval is 500 m.